Development of an Energy Surety Program for Military Applications

Dave Menicucci
Manager, Energy Surety Program Office
Sandia National Laboratories

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Talk Outline

1) Background
2) Define energy surety
3) Discuss energy reliability
4) Developing energy surety microgrids
5) Military applications
6) Summary

Sandia National Laboratories (SNL)

- Largest DOE National Lab, 10,000 staff, $2.2B
- Multi-program lab with security emphasis
- DOD is a principal customer
- Significant work in infrastructure surety

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Distributed Energy Technology Lab

Grid

480V Microgrid

Secure SCADA Lab

Other Remote DER sites

Various Loads

Distributed Energy Resources

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Distributed Generation Technologies

- IC Engines (1 – 10,000 kW)
- Combustion Turbines (300 – 10,000 kW)
- Combined heat and power (300 – 10,000 kW)
- Energy storage (1 – 10,000 kW)
- Wind (0.2 – 5,000 kW)
- Photovoltaics (.01 – 1000 kW)
- Fuel cells (5 – 250 kW)
- Microturbines (30 – 250 kW)
- Diesel (1 – 100 kW)

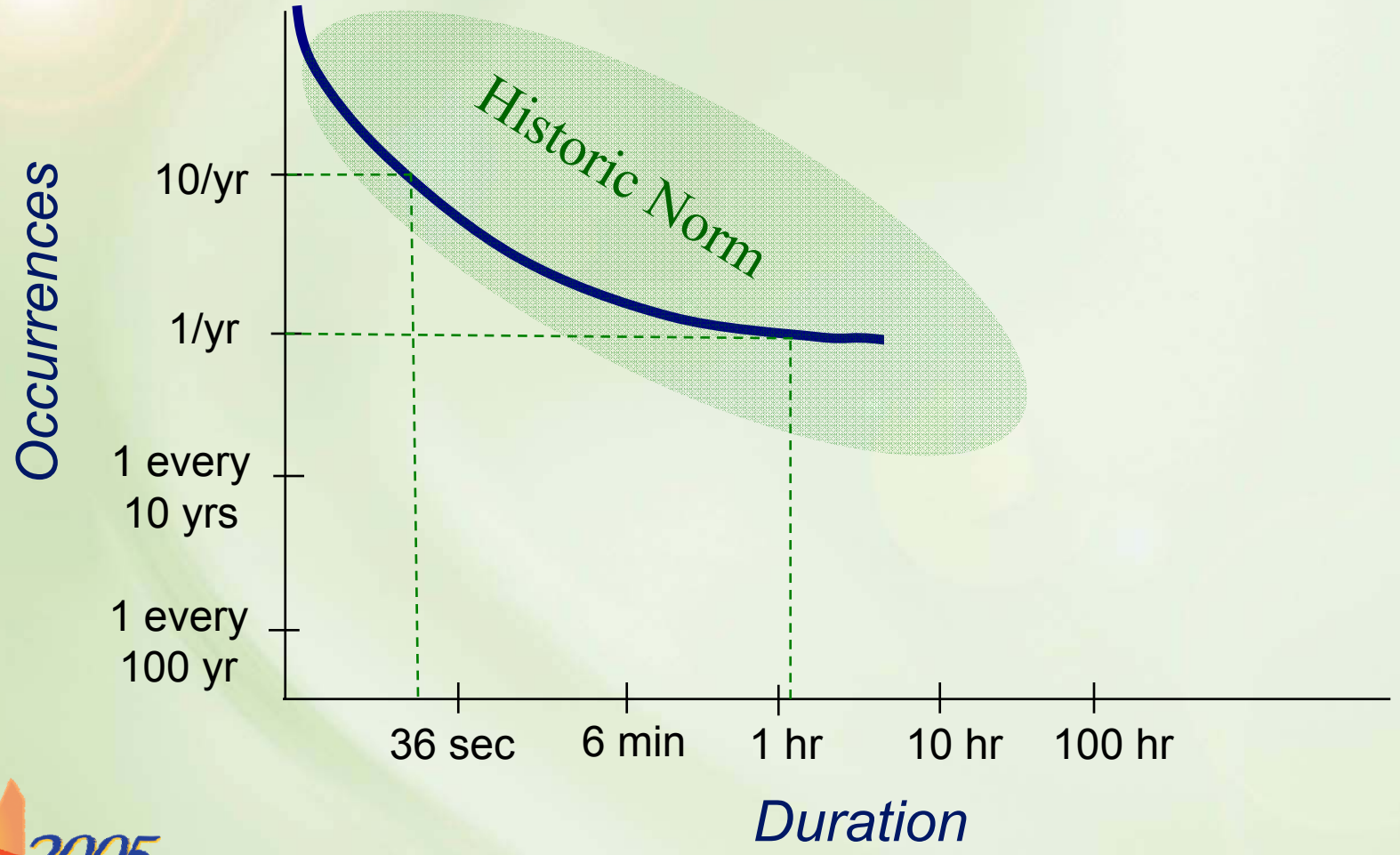
Energy System with High Levels of *Energy Surety*

Energy System is:	If it:
Safe	Safely supplies energy to end user
Secure	Uses diversified energy sources
Reliable	Maintains power when and where needed
Sustainable	It can be maintained indefinitely
Efficient	Produces energy at the lowest cost

Our Present Energy Surety Focus

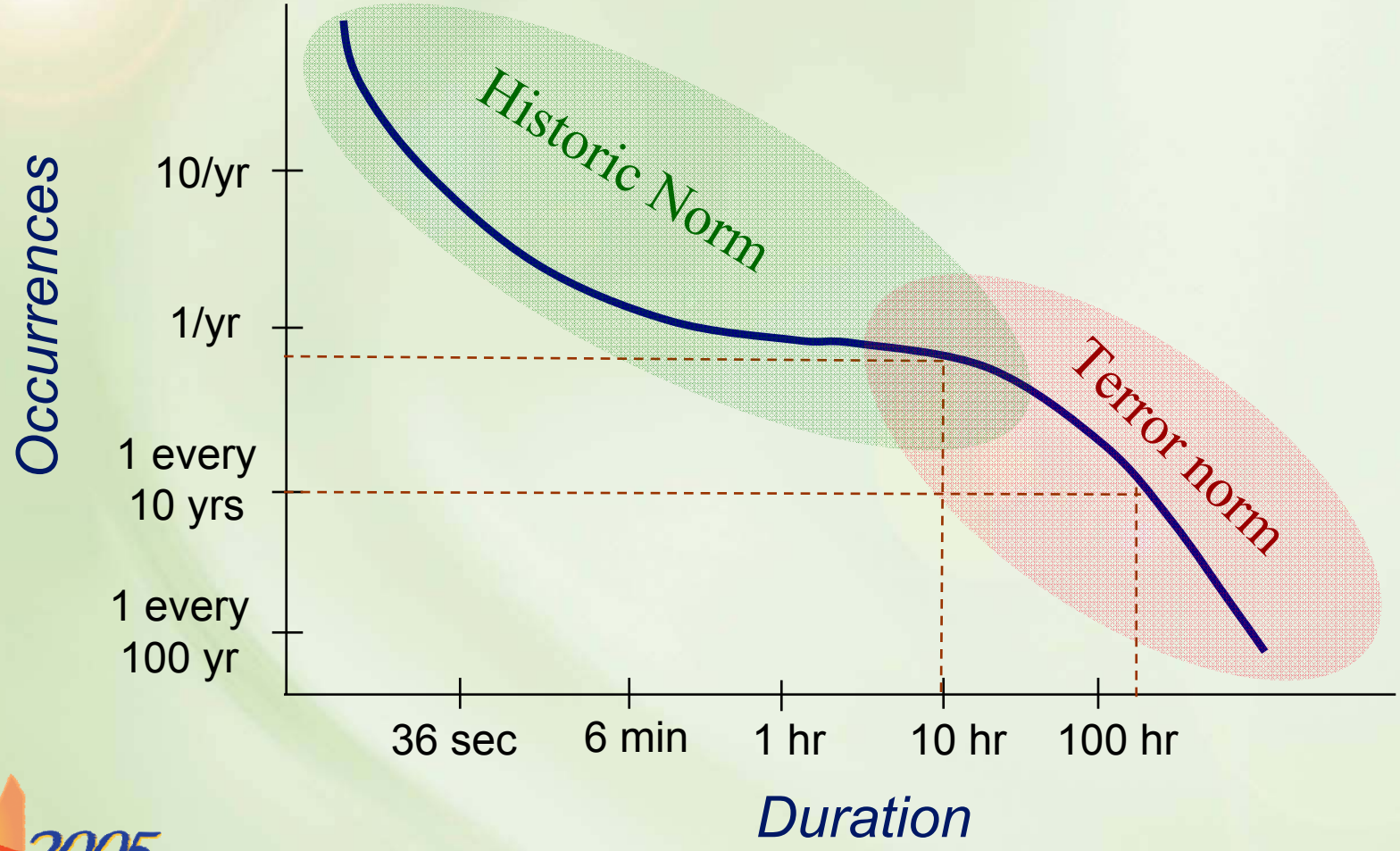
- Power *reliability* and *security*
- Military bases/communities vulnerable to attack
- Other critical infrastructures depend on energy
- New methods for insuring surety are emerging
- Recent evidence of sabotage on hi-tension feeders

Traditional Grid Expectations



Derived from IEEE Telcom Energy Conf, 1998

Impact of Terrorism on Grid Expectations



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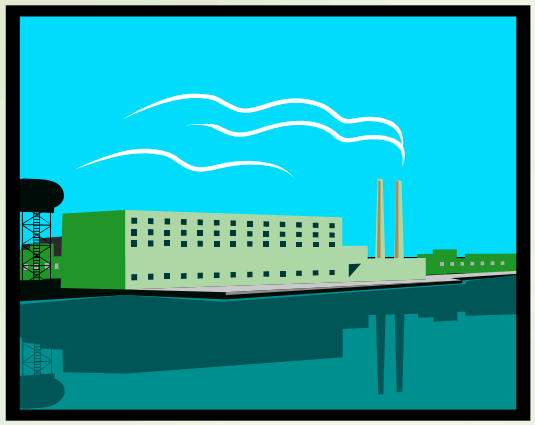
Examples of Outage Costs

- 2,500kW, mid size industrial complex
- 3hr down time
- $105,000-$975,000



- 400kW, mid size office bldg
- 3hr down time
- $12,600-$244,800

*Courtesy: Digital Power Group

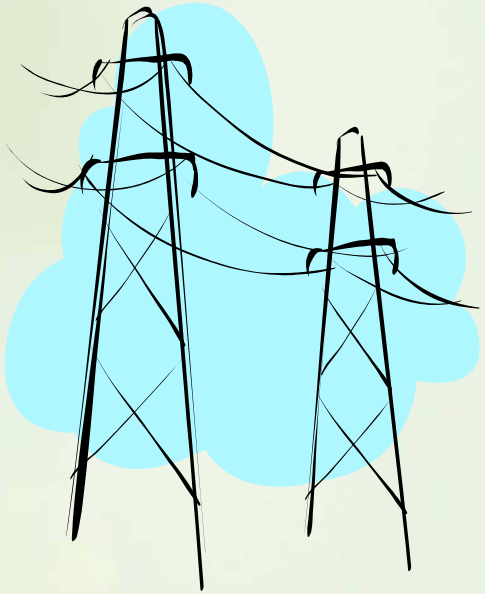
Grid Failures are Inevitable*

- Engineering Axiom: Complexity begets failure
- Grid complexity begets grid failure
- Attempts to harden the grid increase complexity
- More complexity begets more failure

*Fairley, Peter, "The unruly power grid: Advanced mathematical modelling suggests that big blackouts are inevitable," IEEE Spectrum, August, 2004

Saboteurs at Work on the Grid

- Attempt to topple 345kV line poles in Nevada
- Six poles unbolted at base; cascading damage to 40 poles
- Discovery on Dec 27, 2004; reported by DHS



- One of two redundant lines affected; coordinated attack on its twin could have been significant

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Why Energy Surety is an Issue to the Military

- Energy is critical to the mission
- Energy loss affects mission readiness
- Some energy infrastructure is vulnerable

The DOD Energy Surety Wakeup Call

- Ft. Huachuca
  —served by two feeders
- May 2002, fire takes out both feeders
- Base down for 16 hours
  -Cost $3M
  -Potential loss of mission capability

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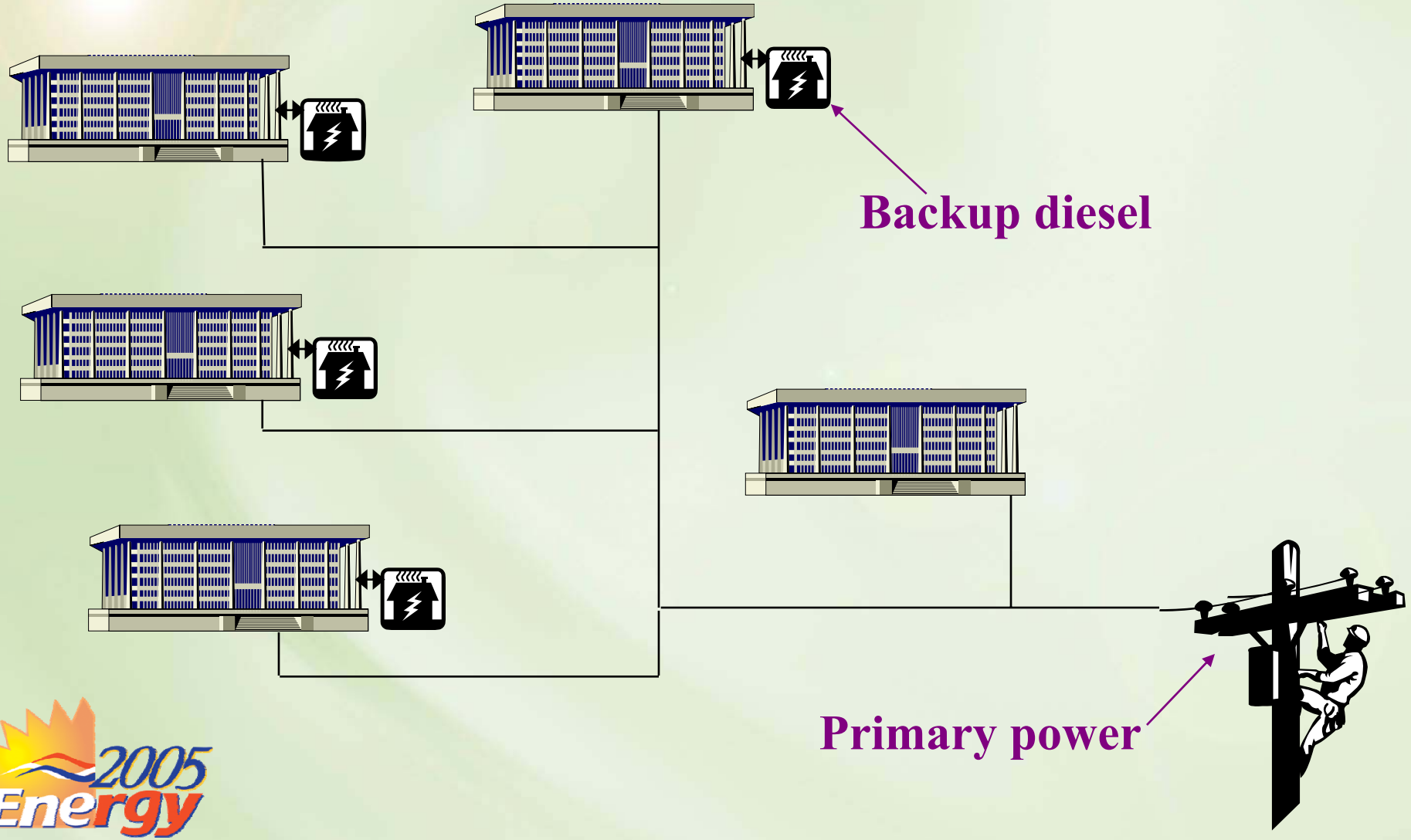
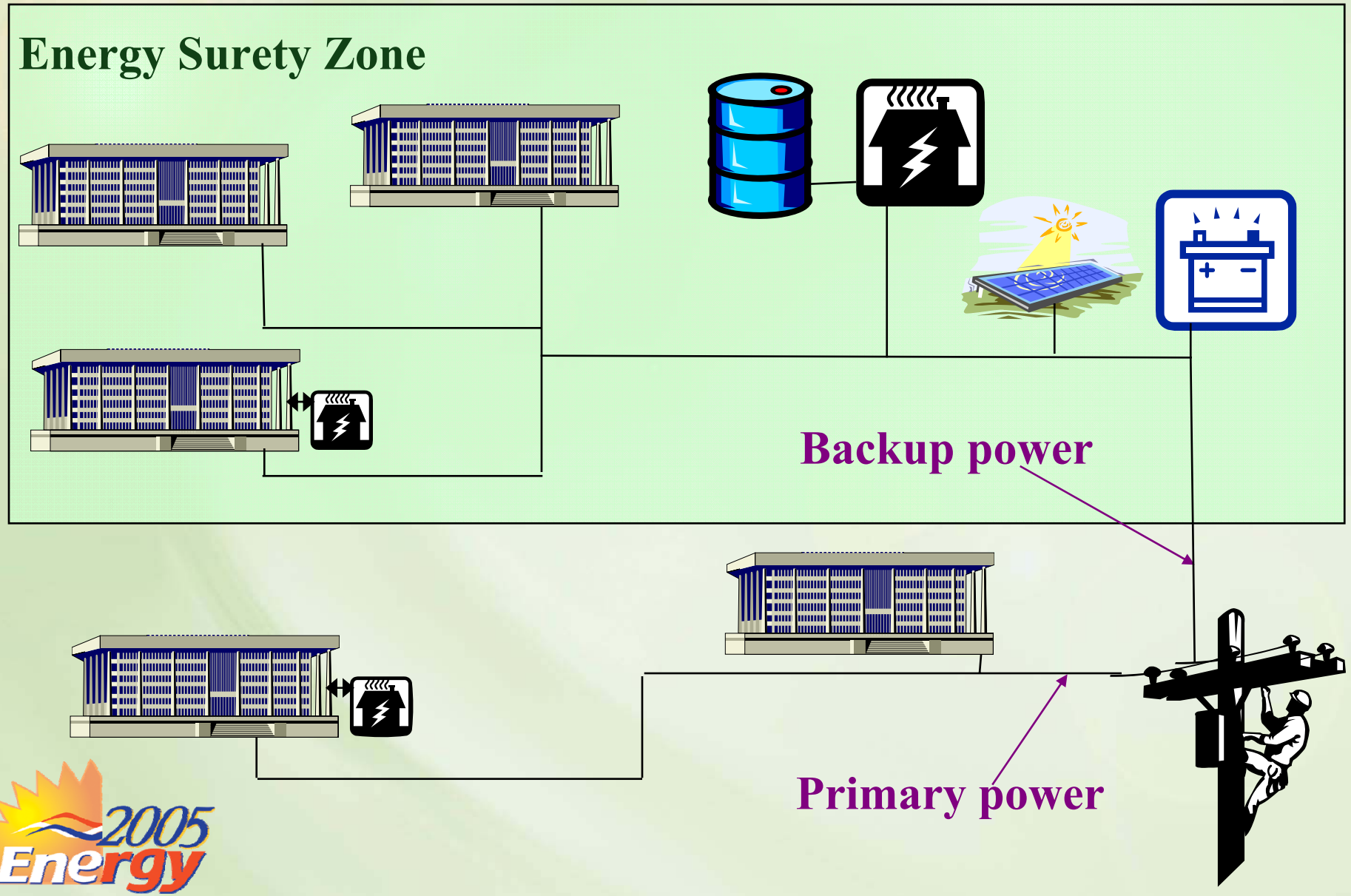
How to Improve Energy Surety

- Disperse the generation; reduce single points of failure
- Run generators full time
- Use proven technologies
- Secure the fuel supply
- Include on-site fuel/energy storage

Traditional Surety Approach



Energy Surety Microgrid



Theoretical Energy Surety Assessment

Surety Levels Outside Energy Surety Zone:

Buildings without backup: 99.95% (5.3 hrs out/year)

Buildings with backup: 99.99% (53 minutes out/year)

Surety Levels Inside Energy Surety Zone:

Determined by:

- ✓Generator type
- ✓Fuel type and its vulnerabilities
- ✓Amount of storage

On-site Fossil Generation Characteristics

- High capacity factor
- Generators proven and understood
- Fuel storage relatively inexpensive
- Fuel supplies can be interrupted
- Fuel stores are dangerous and favored targets

On-site Renewable Generation Characteristics

- No conventional fuel required
- Fuel supply invulnerable to human interruption
- Intermittent operation
- Low capacity factors
- Associated energy storage is relatively expensive

Storage Improves the Surety Value of Generators on Microgrid

- Improves capacity factor
- Improves probability of continuous operation
- Provides stability during islanding sequence

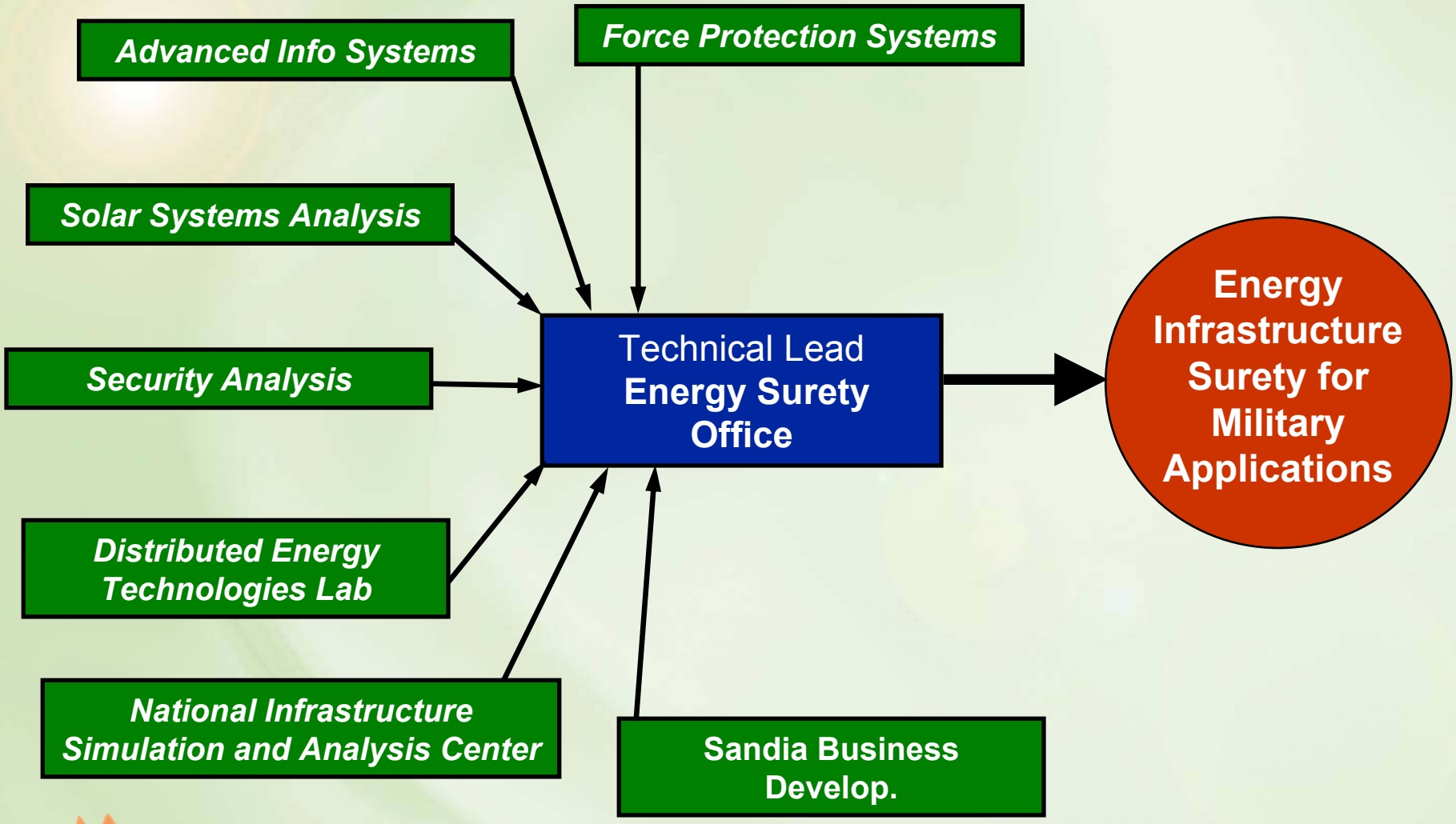
Challenges to Realize Surety Microgrids

- Develop surety requirements:
  --facilities to protect
  --level of protection
  --type of on-site generators
- Optimize the amount of fuel/energy store CRADA)
- Properly control the surety microgrid (agent based)
- Model microgrid's effectiveness (consequence model)
- Complete by spring '06; test at a military base
- Begin widespread implementation

When done, we can visit a base and…

- Review current energy infrastructure weaknesses
- Design correction strategies (e.g., surety microgrids)
- Model the effectiveness of the corrections
  - → without installing hardware
- Manage the hardware installation
- Measure the surety microgrid's effectiveness
- Apply the methodology to bases nationally

Internal Sandia Technical Team



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Project is funded!

Summary

- Energy reliability and security concerns are real
- Military mission readiness depends on reliable energy
- New R&D efforts will produce reliable energy systems